

# Hot Iron

Spring 2015

Issue 87

## Editorial

Is the world really only 'digital'?! Of course its not but my eye was caught by an article in the Times entitled 'It's a litmus test – humans need to be hands-on'. This was actually about a serious proposal that examinations in school science subjects, which normally have practical experiments as part of their course, should be done by the candidate only via a computer screen – ie there would not actually be any practical examination, only questions (and suggestions) as to what would have happened if the experiment was being done for real! This is another example of where computing techniques are swamping our modern lives – nothing wrong with that for most people who are only using these gadgets; but for those of us in situations where some understanding of the underlying technology is required, it is often very much the case that the fundamental laws of that science are glossed over. The more that we get away from practical matters that are best explored in some sort of 'laboratory', the less the understanding of what is actually happening. Years ago when I was interviewing new highly qualified graduates for jobs in electronic engineering, it was striking how few had any concept of the effect of adding capacitance across a high impedance circuit – this was something I learnt on the 'bench' (and in my own radio den!) in a very practical and analogue manner. It was not something that I learnt solely from either reading a book or doing an exercise on a screen - we need to remember that the real world is actually analogue!

This leads directly into how we encourage more youngsters into our hobby. Some would say give them a PC with a dongle, or a Software Defined Receiver, straight away because this will attract their interest. I suggest that if somebody is to get the best out of such gadgets, they must understand a bit about fundamentals of radio techniques; amateur radio is a technical (not just a 'users') hobby so we must actively encourage an understanding of the real physical analogue processes that are involved. For this reason very simple receivers and transmitters need to be built and tried out by our 'new entrants', with them enjoying the success of using something they built, long before they are introduced to the wonders of the latest SDR piece of software. Examination theory and practical aspects need to be matched! Tim G3PCJ

**Contents** Kit Developments – Bath Buildathon, Matching PN junctions, Valved Regen TRF (and on right!), Low Ham Freq scheme, Op Amp configurations, SDR with the Realtek 2832 Dongle, Snippets

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## **Kit Developments**

More head scratching with Steve Hartley has led to minor improvements to the FiveFET to make it able to do the LF bands (as well as the medium wave) more easily. It can now do any one of the bands 20 to 160m just by adding extra resonating capacitors for 80/160m with the number of turns on the toroid adjusted to suit each band. This makes it a suitable companion for the new Fulford AM TX specifically which is specifically designed for new entrants. The **Fulford** uses a crystal or ceramic resonator to produce AM speech on 80 or 160m and will use the FiveFet's 9 volt battery. I am suggesting 160m AM (with initially throw out aerials) is the best approach to get youngsters interested – I hope with the help of the RSGB.

The **Low Ham** is a new 5W peak stand alone transmitter for CW **AND** AM on any band 20 to 160m. It uses a VFO in the range 5 – 6.2 MHz mixed with a 9 MHz crystal (and dividers) for any one of these bands – this approach gives good stability and freedom from chirp etc. This makes it suitable for brand X receivers as well as the Yeo for CW, and the Mark for AM speech. Currently the Mark is limited to the 20 – 80m bands, but I am contemplating an LF version that would do 40, 80 and 160m – a couple of early versions are being tried out.

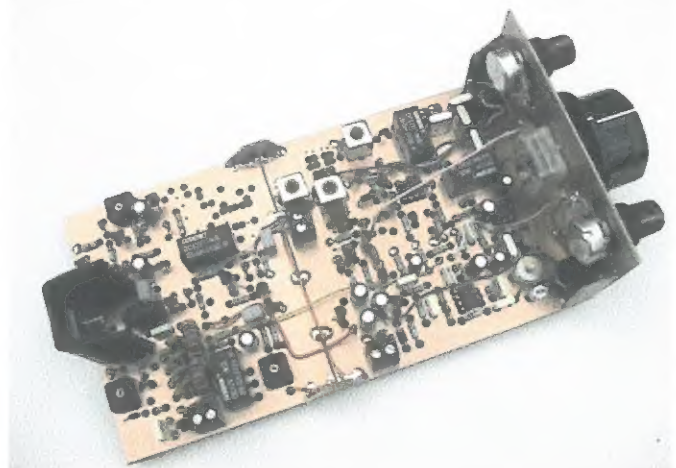
## **Bath Buildathon**

Steve Hartley reports that 'Eleven builders attended the 8th Bath Buildathon and built the Rode Superhet receiver kit from Walford Electronics. Six chose to build for 40m and 5 for 20m. Not everyone finished their kit on the day but comments received suggest everyone enjoyed the event and were inspired to do more radio construction in future. The receivers that were finished were pulling in European SSB signals loud and clear by the end of the day. The Bath Buildathon Crew are providing after event support to see the remaining receivers through to conclusion. Eight builders took away matching Rudge transmitter kits to turn their receivers into 5W SSB transceivers.'

Steve is kindly providing extensive follow up support for those who did not quite finish on the day. Subsequent reports suggest that nearly all of the uncompleted receivers are now working and that two of the Rudge transmitters are also up and running.

Comment by G3PCJ – Steve and his team of helpers do a fantastic job of assisting his builders during what often appears to be a quite challenging first ever electronic building project! Those of you who have had my kits will know that I insist of building the projects in stages, and then doing tests after each stage. Steve's approach goes even further by issuing the parts for each stage in separate envelopes which helps to reduce the risk of mistaken parts, and he often provides a photograph of the PCB for each completed stage! It is a mammoth effort to create this level of 'advice' and his candidates are very lucky.

The Rode is a phone superhet receiver, using a 10 MHz IF so that it can do any single band of 20, 40 or 80m. The receiver has relay TR switches which enable it to act as the single sideband generator when it is coupled up to the Rudge transmitter (right). The TX has an output stage which will produce 5W on a nominal 12 volt supply. Tim



## **Matching P-N junctions** - by Peter Thornton

When building a diode balanced modulator, it's advised that the diodes be "matched", i.e. selected to be near as possible identical, electrically - by using a multimeter on "ohms" and choosing two diodes with equal or very similar "resistance" readings. But, as the old song says, "it ain't necessarily so"! Whilst multimeters will find two diodes of equal forward characteristics, they test at the current the multimeter uses for ohms ranges, and this more often than not isn't the current you use in your designs. My multimeter forces a current of 1mA, and measures the resultant volt drop, so a typical silicon diode, 1N4148, for instance, reads around 0.6 volts. Now imagine these diodes are to be used as the front end mixer in a receiver, driven by the usual buffer amplifier: The diode current might well be very different than 1mA!

Or, perhaps, the mixer is to be used in a transceiver, doing double duty as part of both the TX and Rx. The diodes may well have very different drive currents; from the local oscillator and buffer for Rx, and the audio buffer and microphone for TX duty. Two very different conditions!

Thinking of two diodes leads nicely to measuring transistor junctions, perhaps for checking functionality. The diodes inside the transistor cannot be differentiated - a multimeter can't easily identify collector and emitter, they both read identically at typical meter test currents.

Manufacturers go to great lengths to ensure matched diodes are identical over many decades of current - pico-amps to amps in some instances, measuring the forward voltage drop of the pair as the current is ramped up. It was in such a test set I noticed that extremely low currents, applied to bipolar transistor junctions, I could identify the collector and emitter. The emitter is substantially heavier doped than the collector; thus the forward voltage, base to emitter, is significantly lower than base to collector, and low currents will identify this - typically under 10uA. Your meter will need an input impedance of 10M or more to see these effects.

A test set up for our purposes uses very subtle and esoteric test gear: a 3.3M ohm resistor and a 9 volt battery! Connect the resistor in series with the battery positive (or PSU) and apply the other end of the resistor to the base, found by multimeter ohms testing, (assuming NPN; reverse the polarity for PNP). With a clip lead, connect alternately to each "unknown" leads of the transistor, and measure the voltage, base to lead 1, base to lead 2. The lowest noted voltage is the emitter.

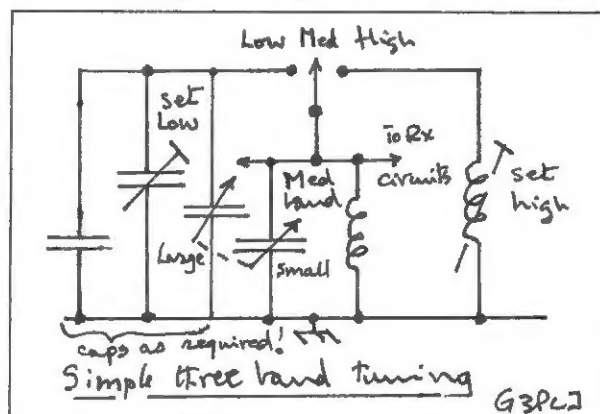
To match two diodes, temporarily connect the anodes, and apply the positive via the test resistor to the junction, and the clip lead alternately to the diode cathodes, as above. 3.3M, 1M, 100k, 10k and 1k test resistors will give 4½ decades of current, plenty adequate for amateur purposes, and measure the voltage across each diode.

This test will yield matched pairs of diodes, and carrier suppression probably won't be an issue in simple symmetrical mixers. You'll be able to see the doping structure inside transistors too. Some high voltage devices (BU208's and 1N4007 for instance) will give much higher junction voltage readings because of the P-I-N structures used to achieve high breakdown ratings.

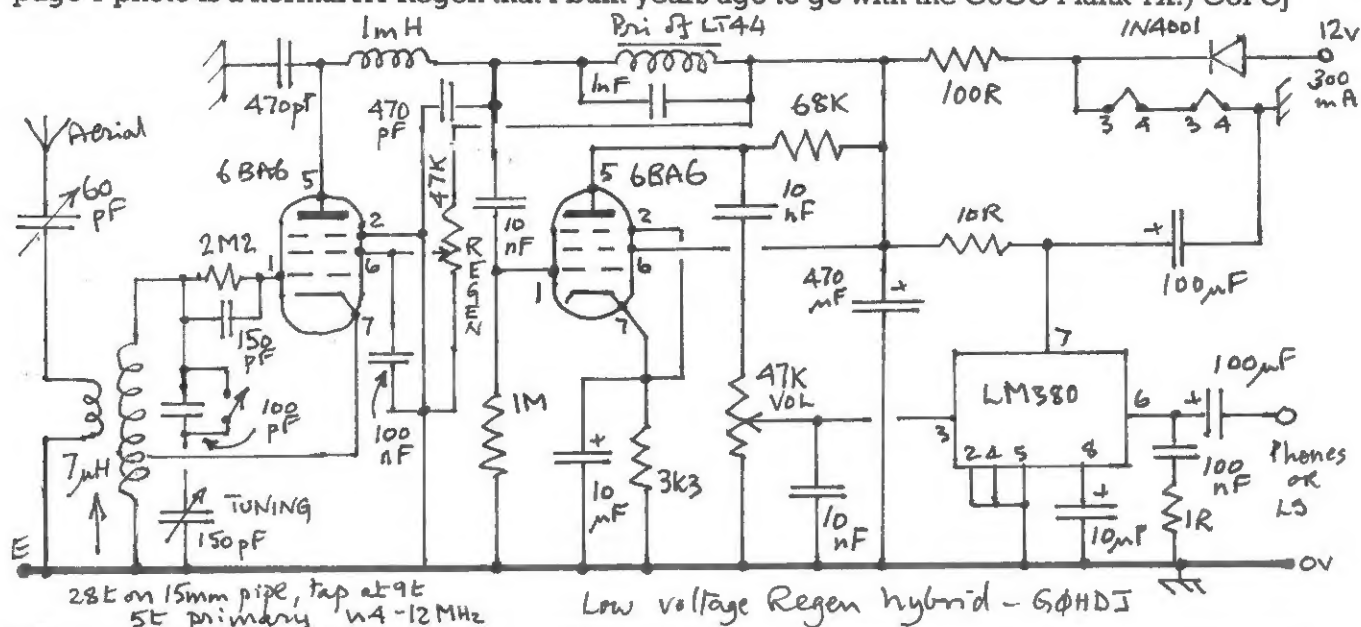
What a simple set up like this can't measure is the device capacitance, as we are using DC test currents. Matching junctions over many decades, DC and AC, is why matched diodes, transistors and SBL-1 mixers cost £££'s, not pennies!

### **Low voltage valved Regen TRF**

This note follows a trawl through my raw material file for something slightly different! Its based on a circuit that Craig Douglas G0HDJ sent me a year or so ago. I love the simplicity of the Regenerative Tuned Radio Frequency (Regen TRF) concept where a single tuned circuit provides all the RF selectivity of the receiver! Absolutely great for multi-band projects – forget all those boring oscillators and mixing schemes with multiple crystals and band pass filters to get rid of all the unwanted mixer products! This particular design is single band; but a single pole centre off switch can add two extra bands very easily (see right). With the switch one way, a lower frequency band can be added by switching extra capacity in parallel; with the switch the other way, it adds inductance in parallel for a higher frequency band. In practice, the extra bands are usually limited to the adjacent amateur bands but it is so simple to do! The original LC values determine the central band frequency. The ‘extra’ capacitor and inductor should be adjustable so that they can be set for the two extra bands.



The design that Craig forwarded has a switched capacitor in series with the tuning capacitor – this is not part of a band changing scheme but is a method of reducing the variable capacitance so that the tuning rate is lower, making it much easier to tune – especially when there is no slow motion drive fitted! It uses the 6BA6 valve for the regen stage and the first audio – these just happen to have a viable performance with a 12 volt HT supply but every few volts of extra supply helps, so I would skip the supply protective diode! The classic problem of how to get a valved amplifier to drive a low impedance loud speaker (without an output audio transformer) is solved in this case by using a LM380 chip – some would say that's cheating! The other nasty components are the two chokes – the 1 mH RF choke is a quite large value for home winding, and the other one (regen stage audio load) is even worse! LT44 transformers are now a bit like hen's teeth! It is used instead of an inductance of a few Henries! Great for those who have them still in their junk boxes! The 'iron' needed for valve projects is their main drawback! (The page 1 photo is a normal HT Regen that I built years ago to go with the G3GC Plank TX!) G3PCJ





## Low Ham Frequency Scheme

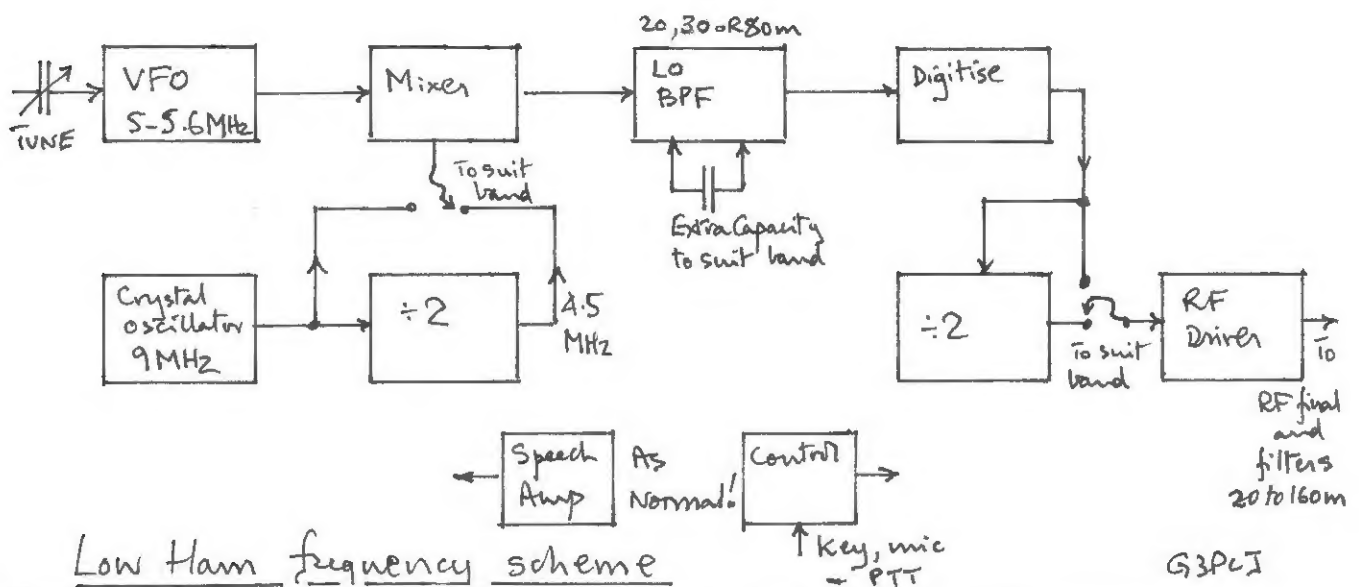
This single band rig is intended to be a companion CW transmitter for the Yeo 20 to 80m DC RX, and for those wanting Amplitude Modulated phone down to 160m. Its needs VFO operation, instead of being rock-bound! So the aim is a design for any band 20 to 160m with the minimum of extra parts for any particular band. 5W peak RF output seems reasonable, so that it will also do AM with a carrier power of 1.25 W peaking up to 5W on speech peaks.

With no need for linear transmitter stages, because CW and AM can be achieved by digital drive to the RF output stage (with following low pass filters), digital techniques can be used – in particular division. To avoid chirping on CW, the VFO must NOT be on the same frequency as the RF output – because it is almost impossible to keep the output RF away from a VFO on the same frequency: this is what causes the small changes in frequency when the TX is activated. Hence we have to use doubling, dividing or a crystal mixing scheme. 14 MHz is also too high for good VFO stability so the crystal mixing approach looks attractive.

Various crystal mixing schemes could be used to give several pairs of bands, but the classic 9 plus or minus 5-5.5 MHz has many advantages – this gives 14 and 3.5 MHz directly depending on whether the mixer adds or subtracts. The desired mixer output can be chosen by adding capacitance to a TOKO 3334 used in its output bandpass filter; so that only one set of mixer filter inductors are needed! The LO signal is then digitised so the mixer output becomes a square wave for driving the RF output stage.

Band	VFO	Xtal	Xtal	Mix	LO	Output
	MHz	MHz	Div	Sum	Out	Div
20	5	9	No	Add	14	No = 14
30	5.6	9	Yes = 4.5	Add	10.1	No = 10.1
40	5	9	No	Add	14	Yes = 7
80	5.5	9	No	Sub	3.5	No = 3.5
160	5.5	9	No	Sub	3.5	Yes = 1.75

Enter the possibility of then also using digital division. The 74HC74 chip contains two D flip-flops that's can each be used to divide by two. The first divider would allow the 20 or 80m filter output to then become 40 or 160m. 30m can be done, without a material change in the VFO range, by using the other divider on the 9 MHz crystal prior to adding in the mixer. The block diagram is like this - G3PCJ



## Op-amp Configurations

These very common and useful amplifiers can be used for many tasks - most often as low frequency amplifiers. With modern FET based devices like the TL071 (single) or TL072 (dual) or TL074 (quad) series, which have negligible input bias currents, one can ignore unequal resistance in the bias current path; for older ones like the 741 and its derivatives, the input bias current path resistances should be similar. The standard chips are TL08X but they cost the same as the generally better low noise ones, TL07X as above, so it is best to use these!

To allow the largest output amplitude possible, it is normal to bias the device's output to the middle of the supply so that the signal can swing an equal amount in either direction. This is done by connecting the positive input (ie the one that makes the output go positive when a positive change is made to that input) to a mid supply DC voltage – this can be derived from a well decoupled high impedance resistive divider. The TL07X series supply can be to 30v.

The two most common circuits are the non-inverting amplifier and the similar inverting version. In the former (see box right), the signal is applied to the op-amp positive input by superimposing it on the bias voltage. Gain is determined mainly by the ratio of the resistors connected to the negative input – the capacitors associated with them normally determine the upper and lower bandwidth:-

$$G_V = 1 + \frac{R_1}{R_2} \quad f_{-3\text{High}} = \frac{1}{2\pi C_1 R_1}$$

$$f_{-3\text{Low}} = \frac{1}{2\pi C_2 R_2}$$

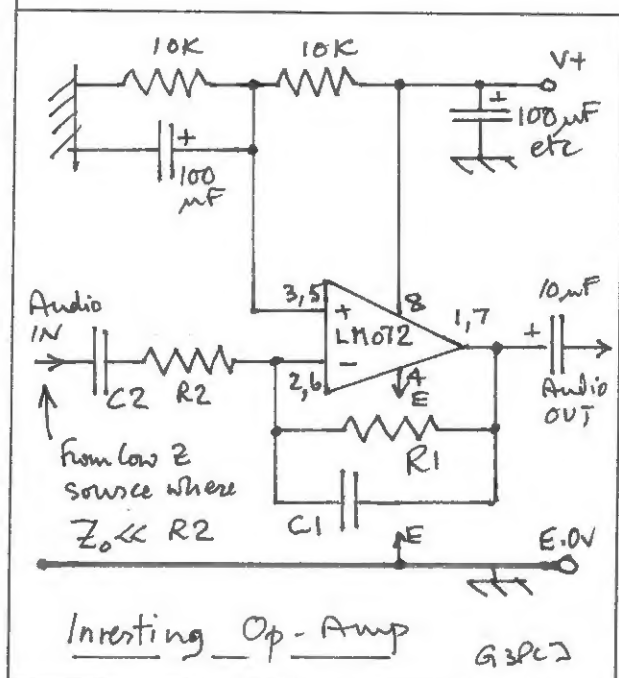
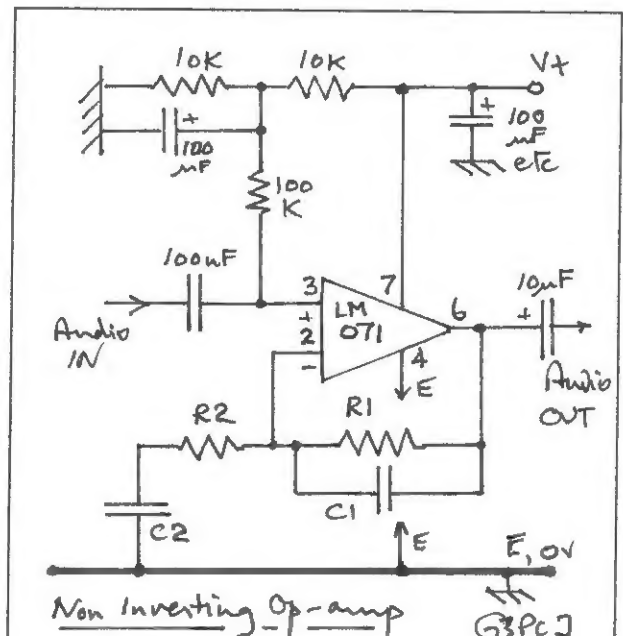
For  $R_1 = 0$   
 $G_V = +1$   
 i.e. buffer

The output (with low impedance) is in phase with the input. Note that in the extreme (and very useful) case of the feedback resistor  $R_1$  being zero, the voltage gain is +1 meaning that it is a plain buffer circuit, with a low impedance output allowing the input to be from a high Z source.

In the inverting version, the signal is applied to the negative input. Bias is fed to the positive input. Gain is slightly lower (G3PCJ):-

$$G_V = \frac{R_1}{R_2} \quad f_{-3\text{High}} = \frac{1}{2\pi R_1 C_1}$$

$$f_{-3\text{Low}} = \frac{1}{2\pi R_2 C_2}$$



## **SDR with the Realtek RTL2832** by Paul Tuton

It has taken me over a year of occasional fiddling when time has permitted to obtain a reasonable performance on the HF bands with this Software Defined Radio. It's not as simple as it might first appear! There is plenty of technical detail on the Internet - perhaps too much - and some of it is conflicting, so I offer these notes as a 'getting started' guide. Nothing more!

**Hardware** - the standard RTL2832 USB 'dongle' (from ebay/China ~£6) provides reception from VHF to over 1GHz. The lower limit is about 30 MHz but is just useable on 27MHz. Ignore the remote controller if sent but the small antenna is useful, also its cable can be cut to provide the right connector for the dongle.

**Software** - Three prominent applications are SDR#, HDSDR and SDR Console - all free off the Internet but do need a decent PC - I use Windows 7 on mine. Beware - these are all capable applications but because they are not produced to exacting commercial standards, they are intolerant of random button clicking, plugging dongles in/out for comparison etc. So try to be careful, especially when you first start otherwise you will probably have software crashes.

SDR# is the easiest to get working and is less sensitive to abuse. The installation routine is unconventional but it works. Pay attention to 'Zadig' which installs the correct drivers for this task. If your interest is VHF, then life is easy and it's the best way to start. Once SDR# is installed and is 'seeing' your dongle, select Wideband FM, tune to a local VHF broadcast station and it should work. You can also try near 433MHz - lots of bleeps, data etc from domestic WX station senders and the like operating in the un-licensed device band.

**HF reception** - When I started, the accepted way to receive HF was to place an 'up-converter' between the antenna and the dongle input. Search 'Ham it Up' (~£35). It's a broadband mixer with a 125MHz oscillator so by tuning SDR# between 126MHz to 155MHz you cover 1 to 30MHz. However, this starts to get complicated with more bits and pieces hung together with a mixture of incompatible connectors and patch leads. I found it hard work and the 125MHz oscillator was not as stable as I hoped. It did produce a reasonable HF RX but with many spurious signals.

So here is another lesson. Extreme band pass filtering at the antenna is essential. Without it, when using a typical 100 foot doublet with average AMU, you'll certainly hear a lot, but all at once! On 40 - 160m, I've had good results with a high-Q loop providing the necessary filtering.

**Direct sampling** - The RTL2832 VHF internal tuner/converter can be bypassed so that HF signals are routed directly to the A-D converter, which is called 'Direct Sampling'. This needs hardware mods on a microscopic scale, but ready modified versions are now available - see photo. For VHF, it operates as a standard dongle, but HF it has the hardware mods already done. When using SDR# or HDSDR, you have the option to configure the RTL2832 for Direct Sampling (Q Branch) and if you forget to do this, you will hear nothing. When switching back to VHF, you must disable Direct Sampling. (Note that SDR Console does not presently have the Direct Sampling option for the RTL2832 so only VHF use is possible.)

My experience with the 'RTL-SDR UV/HF' receiver has been very promising. It is a substantial improvement on the up-converter approach. Just keep in mind that you need tight band pass filtering on the antenna input. (See Mar 15 Radcom review of Elad FDM-DUO TCVR for an explanation of what a modern very capable SDR rig can do now - G3PCJ)





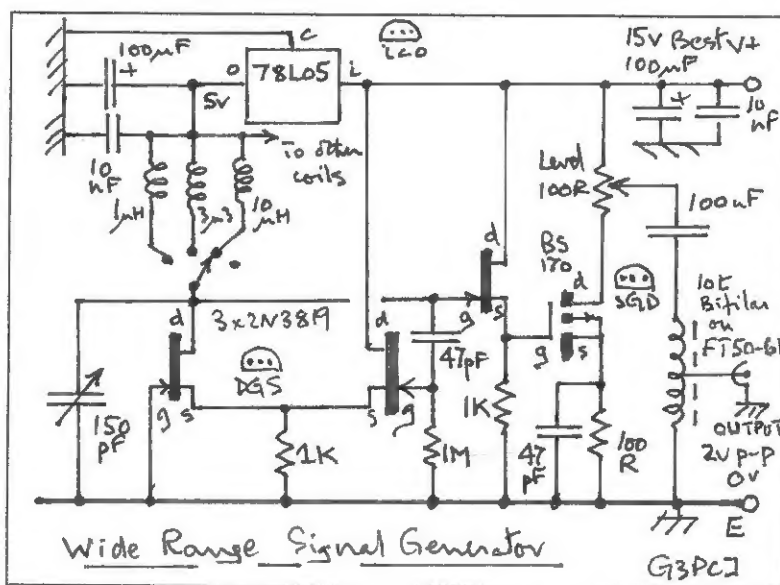
## Snippets

**Crystals in valved oscillators** Following on from Peter T's note about using modern small crystals, Gerald Stancey mentions that the WS76 set was issued with pairs of FT243 crystals in case of damage during use! He warns that HC49 types need care when used in 6V6 Tuned Anode Tuned Grid oscillators. He has successfully 'loaded' 3579 KHz HC49s with solder down to 3575 KHz.

**Solar powered aircraft** Solar Impulse 2 hopes to complete a world circuit powered by 17,248 solar cells with 23% efficiency – these drive four 13.5kW brushless motors with gearing & 2 bladed propellers running at 525 RPM, and also charge a 260 Wh/kg lithium battery weighing 633 Kg (one quarter of aircraft weight) enabling climbing by day to 8,500m altitude, and slow descent by night on the battery to 1500m. Speed is in range 20 – 49 Knots. Wingspan is 72m.

**Radar technology in cars** The advantage of radar is that it can provide fast and clear cut measurement of velocity and proximity of multiple objects under any weather conditions. Cost is coming down and increased help to avoid accidents is a high priority. Four bands at 24 GHz are currently used but from 2022 the band 77 – 81 GHz will have to be used. Signal bandwidth determines range resolution with 4 GHz being desired. Complex transmit waveforms are used with Linear Frequency Modulated Continuous-Wave in 'chirped' pulses, to extract speed and distances to multiple objects. Inevitably, the very high data flow from the receiver is processed by means of I and Q channels in a powerful dedicated processor. If the RF is below about 67 GHz, direct sampling can be used but for the higher bands heterodyne converters have to be used to lower the data stream to an IF that can be sampled directly.

**Simple Sig Gen** I often need a wide frequency range generator that does not need high stability. The circuit right is a derivative of my Dipper and is very forgiving of resonator L and C values. I have eight coils in 1, 3.3, 10, 33..... uH sequence which gives approx 33 MHz to 200 KHz. The BS170 buffer amp stage with 2:1 transformer gives a low output impedance and about 2 volts p-p. It will work on a 12v supply but 15v gives better waveshapes. G3PCJ



## 31<sup>st</sup> Yeovil ARC QRP Convention

This takes place, as in recent years, at The Digby Hall in Sherborne on April 12 2015, with the doors opening at 0930. Admission is £3. There will be traders (including Walford Electronics), bring and buy, Club stalls, and RSGB, RAFARS and RASRS will also be present. If any Construction Club member plans to collect a kit, please give me advance warning! There will be two talks – 'A remarkable HF propagation path' by Rob G3MYM, and 'What's new in SDR?' by Jim Gailer G3RTD.